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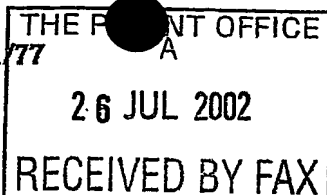
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1. Your reference

P30916/IKE/JBR

2. Patent application number

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26 JUL 2002

0217295.5

3. Full name, address and postcode of the or of each applicant (underline all surnames)

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Patents ADP number (*if you know it*)

06748818001

08433633001

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

Seal Assembly

5. Name of your agent (*if you have one*)

Murgitroyd & Company

"Address for service" in the United Kingdom
to which all correspondence should be sent
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Patents ADP number (*if you know it*)

1198015

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Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77) 1

Request for substantive examination (Patents Form 10/77)

Any other documents (please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature *Jo Bradley*
Murgitroyd & Company

Date 26 July 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

Jo Bradley

0141 307 8400

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DUPLICATE

1

Seal Assembly

1 The present invention relates to double-walled
2 pipelines used for transporting fluids such as oil
3 and gas. In particular it relates to a seal
4 assembly for use in sealing an annular space between
5 an inner pipe and an outer pipe in such a double-
6 walled pipeline.

7
8 Pipelines carrying heavy or crude oil need to be
9 thermally insulated as heavy oil tends to solidify
10 during transport from a subsea production well to
11 the surface due to heat losses in the submerged
12 pipeline. Thermal insulation is also required to
13 avoid the formation of hydrates which can occur for
14 certain crude oil compositions when the crude oil
15 cools down, for example, when there is a breakdown
16 in production flow rate.

17
18 Production lines which require a high level of
19 thermal insulation typically use a double-walled
20 pipe structure, for example a pipe-in-pipe system.
21 A pipe-in-pipe system comprises an internal pipe
22 within an external pipe separated by an annulus

1 volume. In such a structure, the annular space can
2 be filled with thermal insulation material. This
3 structure has the advantage that the external pipe
4 keeps the annular space dry and so, for example, in
5 subsea pipelines, the thermal insulation material is
6 protected from water. A further advantage of this
7 structure is that the pressure in the annulus can be
8 different from that outside the external pipe and
9 that inside the internal pipe. This is important if
10 the insulating material has a particular pressure
11 requirement or if a vacuum or partial vacuum is to
12 be used for insulating purposes. For example, the
13 annulus can be at atmospheric pressure while the
14 hydrostatic pressure experienced by the external (or
15 carrier) pipe and the internal pressure of the fluid
16 in the internal pipe (flowline) are different.
17 Furthermore it is interesting to lower the pressure
18 in the annulus in order to increase the thermal
19 insulation performance.

20
21 One of the problems associated with such pipelines
22 is that of safeguarding the annular space against
23 the ingress of water, for example due to leaks in
24 the external or carrier pipe. Water in the annular
25 space will conduct heat from the inner flowline to
26 the carrier pipe thus destroying the effectiveness
27 of the insulation. This problem has been approached
28 in prior art pipe-in-pipe systems by
29 compartmentalising the annular space by means of
30 permanent seals (GB 2 317 934, US 2 930 407, WO
31 00/09926). It is desirable, in some cases, to have
32 a vacuum or partial vacuum in the annular space.

1 When the annular space is compartmentalised by
2 permanent seals, the vacuum or partial vacuum in the
3 annular space must be created during the manufacture
4 of the double walled pipe. Once manufactured, it is
5 then not possible to vary the pressure within the
6 compartments, for example, so as to maintain the
7 required pressure throughout the lifetime of the
8 pipe. An ability to vary this pressure would be
9 useful, for example, in the case of diffusion of
10 gases into the annulus through the internal or
11 external pipes or a leak which modifies the pressure
12 within the compartment and alters the thermal
13 insulation capabilities of the pipeline. There
14 remains a need for a pipeline for which the pressure
15 within the annular space can be controlled during
16 the lifetime of the pipeline and a pipeline for
17 which the annular space can be separated into
18 compartments in the case of a leak of water or
19 hydrocarbon fluids into the pipeline, thus
20 preventing flooding of the whole annular space.
21 The above problems are solved by the seal assembly
22 of the present invention.

23
24 In accordance with the invention there is provided a
25 seal assembly for sealing an annular space between
26 an inner and an outer pipe in a double-walled subsea
27 pipeline which seal assembly under normal operating
28 conditions is in a non-sealing position which allows
29 the passage of a gas through said seal assembly and
30 which seal assembly is actuatable from a non-sealing
31 position to a sealing position in response to the
32 entry of liquid into said annular space.

1
2 Preferably the seal assembly in its non-sealing
3 position provides an opening in the annular space to
4 allow the passage of a gas through the seal
5 assembly. Preferably the seal assembly comprises an
6 annular member and moveable blocking means such that
7 entry of liquid into said annular space causes
8 movement of said blocking means to close said
9 opening.

10
11 Preferably the blocking means is moveable under
12 pressure of liquid flow or the seal assembly
13 comprises a liquid-sensitive material and the
14 blocking means is moveable as a result of
15 interaction of the liquid with said liquid-sensitive
16 material.

17
18 Embodiments of the invention will now be described,
19 by way of example only, with reference to the
20 accompanying drawings in which:

21
22 Figure 1a is a cross-sectional view of a seal
23 assembly according to a first aspect of the present
24 invention.

25
26 Figures 1b and 1c are cross-sectional views of a
27 seal assembly according to a first aspect of the
28 present invention in non-sealing and sealing
29 positions respectively.

30
31 Figure 1d is a cross-sectional view of a closure
32 member and a plan view of a closure member.

1
2 Figure 1e is a cross-sectional view of a diaphragm
3 and a plan view of a diaphragm.
4

5 Figures 2a and 2b are perspective views of a valve
6 for insertion into a seal assembly according to the
7 second aspect of the present invention. In Figure
8 2b, the valve is in its non-sealing position.
9

10 Figures 3a and 3b are cross-sectional views of a
11 valve for insertion into a seal assembly according
12 to the second aspect of the present invention, in
13 non-sealing and sealing positions respectively.
14

15 Figures 3c and 3d are cross-sectional views of a
16 valve for insertion into a seal assembly according
17 to the second aspect of the present invention, in
18 non-sealing and sealing positions respectively.
19

20 Figures 4a to 4d are cross-sectional views of a seal
21 assembly according to the third aspect of the
22 present invention. In Figures 4b and 4c, the seal
23 assembly is in a non-sealing position in the annular
24 space between an outer pipe and an inner pipe.
25

26 Referring now to the drawings Figure 1a shows a seal
27 assembly according to a first aspect of the present
28 invention. In the first aspect of the present
29 invention the annular member (1) comprises one or
30 more orifices (5) and the moveable blocking means
31 comprises a diaphragm (2) and a closure member (4)
32 such that flow of liquid in said annular space

1 causes movement of the diaphragm which causes
2 movement of the closure member to close said one or
3 more orifices.

4
5 Preferably the annular member is capable of
6 extending from the inner wall of the outer pipe to
7 the outer wall of the inner pipe and of being in
8 sealing contact with each of said inner and outer
9 walls. By sealing contact is meant that the passage
10 of gas or liquid through the contact interface is
11 not possible. This is achieved by the appropriate
12 dimensioning of the annular member. Figures 1b and
13 1c show the annular member in sealing contact with
14 each of the inner and outer walls of the annular
15 space in a pipe-in-pipe structure. Preferably the
16 annular member is made from a rubber material or an
17 elastomeric material, for example polyurethane. The
18 annular member may comprise a steel insert (4) for
19 strengthening/rigidity purposes.

20

21 Preferably the annular member has a longitudinal end
22 face which is recessed i.e., it has a concave cross-
23 section defining upper and lower arms. Upper and
24 lower relate to the larger circumference and the
25 smaller circumference sides which define the end
26 face of the annular member, respectively.

27 Preferably, the larger diameter of the recessed end
28 face is larger than that of the outer pipe and the
29 smaller diameter of the recessed end face is smaller
30 than that of the inner pipe of the pipe-in-pipe
31 structure in which the annular member is to be used.
32 This is so that in order to fit into the annular

1 space, the annular member must be compressed at the
2 recessed end. Once inserted into the annular space,
3 the recessed end will try to expand, thus wedging
4 the annular member in place.

5
6 Figure 1b shows a cross-section of the above seal
7 assembly in an annular space between inner and outer
8 pipes in a non-sealing position. In this non-
9 sealing position, gas can pass through the seal
10 assembly via apertures (6,7) in the diaphragm, via a
11 gap between the annular member and the closure
12 member and via orifice (5) in the annular member.
13 The annular member may have one or more orifices;
14 the number and size of which will depend on
15 application parameters, for example, the dimensions
16 of the inner and outer pipes, the repartition of the
17 waterstops along the pipeline, the length of the
18 pipeline, the sensitivity of the moveable blocking
19 means.

20
21 In this embodiment, both the diaphragm and the
22 closure member are moveable. Preferably the closure
23 member is annular in shape as can be seen from the
24 embodiment shown in Figure 1d. In the embodiment
25 where the annular member has a longitudinal end face
26 which comprises a concave cross-section defining
27 upper and lower arms, the closure member may be
28 attached by resilient means to one of the upper and
29 lower arms of the annular member. Preferably there
30 is a gap between the closure member and the other
31 arm of the annular member to allow flow of gas past
32 the closure member when the seal assembly is in a

1 non-sealing position. The closure member may
2 comprise protrusions (8) positioned on the closure
3 member so that they correspond in position to the
4 one or more orifices in the annular member that they
5 are intended to plug. The protrusions are shaped so
6 that when pressed against an orifice they will form
7 an effective seal.

8
9 Preferably the diaphragm is annular in shape as can
10 be seen from the embodiment shown in Figure 1e. In
11 the embodiment where the annular member has a
12 longitudinal end face which comprises a concave
13 cross-section defining upper and lower arms, the
14 diaphragm may extend between the upper and lower
15 arms of the annular member and comprise apertures to
16 allow flow of gas through the diaphragm when the
17 seal assembly is in a non-sealing position. The
18 diaphragm may be buckled in shape to increase the
19 efficiency of its function as shown in Figure 1e.

20
21 Preferably both the diaphragm and the closure member
22 are annular in shape. In a preferred embodiment,
23 the annular member has a longitudinal end face which
24 comprises a concave cross-section defining upper and
25 lower arms; the closure member is attached by
26 resilient means to one of said upper and lower arms;
27 and the diaphragm extends between said upper and
28 lower arms.

29
30 Under normal operating conditions, i.e., when the
31 pipeline is not leaking and there is no ingress of
32 liquid into the annular space, the seal assembly is

1 in its non-sealing position. Should liquid leak
2 into the annular space, the flow of liquid in the
3 annular space causes movement of the diaphragm which
4 causes movement of the closure member, which in turn
5 closes the one or more orifices. Preferably the
6 pressure of the liquid acts directly on the
7 diaphragm causing the diaphragm to press against the
8 closure member causing the closure member to move
9 into a position where it closes the one or more
10 orifices. The apertures in the diaphragm are closed
11 on contact with the closure member. The seal
12 assembly in its sealing position is shown in Figure
13 1c. The direction of liquid flow is indicated by the
14 arrows. In this first aspect of the invention, the
15 liquid must flow towards the diaphragm to actuate
16 the seal assembly from a non-sealing position to a
17 sealing position.

18
19 In a second aspect of the present invention the
20 annular member comprises one or more valves and said
21 valves each comprise one or more orifices and
22 moveable blocking means such that the flow of liquid
23 in said annular space causes movement of the
24 moveable blocking means to close said one or more
25 orifices.

26
27 A valve comprises one or more orifices and moveable
28 blocking means. Figures 2 and 3 show embodiments of
29 valves according to this aspect of the invention.
30 The valve may comprise a housing which has one or
31 more orifices and which houses the moveable blocking
32 means. The valve may also be connected to tubing or

1 hosing. The tubing or hosing may form an integral
2 part of the housing. The valve may be situated
3 within the tubing or hosing. The one or more valves
4 may be attached to or form part of the annular
5 member. Preferably the valve (and, if present,
6 tubing) is insertable into the annular member.
7 Preferably the annular member comprises one or more
8 tubes in which tubes the one or more valves are
9 situated.

10
11 In this second aspect of the invention the valve may
12 be located on either face of the annular member,
13 i.e., either on the face that confronts the flow of
14 liquid or on the opposite face.

15
16 Figure 2a shows a valve (9) and tubing (10)
17 arrangement that can be inserted into the annular
18 member. In this embodiment of the second aspect of
19 the present invention a valve comprises a blocking
20 plate (16) with an orifice and the moveable blocking
21 means comprises a diaphragm (14) and a closure
22 member (12) which closure member has apertures (15)
23 such that flow of liquid in the annular space causes
24 movement of the diaphragm which causes movement of
25 the closure member against the blocking plate
26 closing the orifice in the blocking plate and the
27 apertures in the closure member. The valve
28 comprises a housing (11) in the shape of a truncated
29 cone and this may be located at the end of tubing.
30 A membrane or diaphragm that is permeable to gas but
31 not liquid covers the end of the housing having the
32 larger diameter. The end of the housing having the

1 smaller diameter (the nose) of the housing is formed
2 by a blocking plate or ring (16) which has an
3 orifice in it. In this embodiment the closure member
4 comprises a plug having the shape of a truncated
5 cone (13) which fits in a sleeve-like fashion into
6 the housing. The nose of the plug has orifices in
7 it. A retaining nut (17) holds the conical plug in
8 place inside the housing in a preloaded position so
9 that the nose of the plug is at a distance from the
10 blocking plate or ring. This is the non-sealing
11 position and is shown in Figure 2b. When there is
12 sufficient pressure of liquid on the membrane, the
13 membrane will push on the conical plug so that it
14 comes into contact with blocking plate and closes
15 off the orifices.

16
17 Preferably the diaphragm is made of Gortex
18 (trademark) and preferably the rest of the moveable
19 means is made of a rubber type material. Silicone
20 grease may be used during assembly on all sliding
21 faces.

22
23 In this embodiment the valve may be located on
24 either face of the annular member, i.e., either on
25 the face that confronts the flow of liquid or on the
26 opposite face. In either location the direction of
27 the flow of liquid should be such that it confronts
28 the diaphragm before the blocking plate.

29
30 Figure 3 shows two further embodiments of a valve
31 according to the second aspect of the present
32 invention. In these embodiments the moveable

1 blocking means comprises biased means attached to a
2 closure member which biased means is held in a
3 biased position by means of a liquid-sensitive
4 material such that the presence of liquid in said
5 annular space causes interaction of said liquid with
6 said liquid-sensitive material causing said liquid-
7 sensitive material to release the biased means so
8 that said biased means effects movement of the
9 closure member to close said one or more orifices.

10
11 Figure 3a shows valve (18) in a non-sealing position
12 which comprises housing (19); orifices (20, 21) and
13 tubing (22). In this embodiment the valve housing
14 is in the shape of truncated tubing and has orifices
15 in the side walls as is shown in Figures 3a and b.
16 The moveable blocking means comprises biased means
17 (23) attached to a closure member (24). The biased
18 means may be either a compression or a tension
19 spring, preferably the biased means is a tension
20 spring. The biased means is held in a biased
21 position, for example a spring held in a compressed
22 state, by means of liquid-sensitive material (25).
23 Interaction with liquid in the annular space causes
24 the liquid-sensitive material to react or dissolve
25 thus releasing the biased means. Release of the
26 biased means causes movement of the closure member
27 into a position where it closes off the one or more
28 orifices in the valve head. The valve in its
29 sealing or closed-off position is shown in Figure
30 3b. Preferably, in this embodiment the valve is
31 located on the face of the annular member that
32 confronts the flow of liquid.

1
2 Figures 3c and d show a further embodiment of a
3 valve for insertion into a seal assembly according
4 to the present invention, in non-sealing and sealing
5 positions respectively. Figure 3c shows valve (18)
6 which comprises housing (19), orifices (20, 21) and
7 tubing (22). The moveable means comprises a biased
8 spring (23) and closure member (24). The spring is
9 held in a compressed state by means of a retaining
10 wire (26) which is restrained in position by a
11 liquid-sensitive material (25). When liquid enters
12 the annulus the liquid sensitive material will react
13 or dissolve on contact with the liquid, releasing
14 the retaining wire and simultaneously releasing the
15 spring. On release, the spring pushes closure
16 member (24) to close off the orifices (see Figure
17 3d).
18
19 Preferably the liquid-sensitive material is a salt
20 that will dissolve or partially dissolve on contact
21 with the liquid or an absorbent material that will
22 soften on contact with the liquid.
23
24 In a third aspect of the present invention the
25 annular member is dimensioned so that it will be in
26 sealing contact with only one of the inner wall of
27 the outer pipe and the outer wall of the inner pipe
28 and will provide an opening in said annular space
29 between the annular member and the wall with which
30 it is not in sealing contact and the moveable
31 blocking means comprises resilient means which is

1 deformable under the pressure of liquid flow in the
2 annular space to close said opening.

3
4 An embodiment according to this aspect of the
5 invention is shown in Figure 4. The seal assembly
6 of Figure 4 comprises an annular member (27) and
7 moveable blocking means (28). Figures 4a and 4b
8 show the seal assembly in a non-sealing position in
9 a pipe-in-pipe structure. The annular member is
10 capable of being in sealing contact with only one of
11 the inner wall of the outer pipe (31) and the outer
12 wall of the inner pipe (32) thus providing an
13 opening (33) in said annular space (30) between the
14 annular member and the wall with which it is not in
15 sealing contact. This is achieved by the
16 appropriate dimensioning of the annular member.
17 Preferably the annular member is capable of being in
18 sealing contact with only the outer wall of the
19 inner pipe.

20
21 In this aspect of the invention the moveable member
22 comprises resilient means which is deformable under
23 the pressure of liquid flow. The moveable member
24 may be a lip on the annular member. Preferably the
25 annular member and the moveable member are made from
26 the same material. Preferably the annular member
27 has a longitudinal end face which comprises a
28 concave cross-section defining (or has a recess
29 which defines) upper (28) and lower (34) arms and
30 one of these arms is the resilient means deformable
31 under the pressure of liquid flow in the annular
32 space. Upper and lower relate to the larger

1 circumference and the smaller circumference sides
2 which define the end face, respectively. Preferably
3 the lower arm is in sealing contact with the upper
4 wall of the inner pipe. In this embodiment the
5 upper arm is the resilient means moveable under the
6 pressure of liquid flow.

7
8 Preferably, the larger diameter of the end face is
9 larger than that of the outer pipe and the smaller
10 diameter of the end face is smaller than that of the
11 inner pipe of the pipe-in-pipe arrangement in which
12 the annular member is to be used. This is so that
13 in order to fit into the annular space, the annular
14 member must be clamped closed and held in this
15 position by an annular restraining means (35). The
16 annular restraining means has a complementary shape
17 to the concave recess in the end face of the annular
18 member. Preferably the annular restraining means is
19 bonded (36, 37) to the lower and upper arms
20 respectively of the annular member, thus restraining
21 them from moving apart. This bond may be made by a
22 water-soluble glue/adhesive.

23
24 In this third aspect of the invention the
25 longitudinal end face having a recess confronts the
26 flow of liquid. In operation, flow of liquid will
27 exert force on this end face. The most vulnerable
28 component of the seal assembly to this force is the
29 upper arm (moveable means) and when the force is
30 sufficient to break the bond between it and the
31 annular restraining means, the upper arm is pushed

1 against the inner wall of the upper pipe thus
2 effecting a seal (see Figure 4c).

3
4 The present invention also provides a pipe system
5 comprising an inner pipe and an outer pipe and a
6 seal assembly selected from the seal assemblies
7 described herein. Preferably the seal assemblies
8 are installed in pairs in order to prevent the
9 passage of liquid in both directions. The annular
10 space in the pipe system may also comprise
11 insulation material and/or one or more elements
12 chosen from bulkheads to transfer loads (services or
13 handling loads) between the carrier pipe and the
14 flowline; spacers to centre the flowline within the
15 carrier pipe; buckle arrestors to prevent the
16 propagation of a buckle along the carrier pipe.
17 Preferably the seal assemblies are installed near to
18 buckle arrestors so that when buckle propagation is
19 stopped, any water leak due to the buckle will not
20 be allowed to proceed through the pipeline.

1 CLAIMS

2 1. A seal assembly for sealing an annular space
3 between an inner and an outer pipe in a double-
4 walled subsea pipeline which seal assembly:

5 (a) under normal operating conditions is in a
6 non-sealing position which allows the
7 passage of a gas through said seal
8 assembly; and

9 (b) is actuatable from a non-sealing position
10 to a sealing position in response to the
11 entry of liquid into said annular space.

12
13 2. A seal assembly according to claim 1 which

14 (a) in its non-sealing position provides an
15 opening in the annular space to allow the
16 passage of a gas through the seal
17 assembly; and

18 (b) comprises an annular member and moveable
19 blocking means such that entry of liquid
20 into said annular space causes movement of
21 said blocking means to close said opening.

22
23 3. A seal assembly according to claim 2 wherein
24 the blocking means is moveable under pressure
25 of liquid flow.

26
27 4. A seal assembly according to claim 2 which
28 comprises a liquid-sensitive material and
29 wherein the blocking means is moveable as a
30 result of interaction of the liquid with said
31 liquid-sensitive material.
32

- 1 5. A seal assembly according to claim 3 wherein
2 (a) the annular member comprises one or more
3 orifices; and
4 (b) the moveable blocking means comprises a
5 diaphragm and a closure member such that
6 flow of liquid in said annular space
7 causes movement of the diaphragm which
8 causes movement of the closure member to
9 close said one or more orifices.
10
- 11 6 A seal assembly according to claim 5 wherein
12 the diaphragm and closure member are both
13 annular in shape.
14
- 15 7 A seal assembly according to any one of claims
16 2 to 4 wherein:
17 (a) the annular member comprises one or more
18 valves; and
19 (b) said valves each comprising one or more
20 orifices and moveable blocking means such
21 that flow of liquid in said annular space
22 causes movement of the moveable blocking
23 means to close said one or more orifices.
24
- 25 8 A seal assembly according to claim 7 wherein a
26 valve comprises a blocking plate with an
27 orifice and the moveable blocking means
28 comprises a diaphragm and a closure member
29 which closure member has apertures such that
30 flow of liquid in the annular space causes
31 movement of the diaphragm which causes movement
32 of the closure member against the blocking

- 1 plate closing the orifice in the blocking plate
2 and the apertures in the closure member.
3
- 4 9 A seal assembly according to claim 7 wherein
5 the moveable blocking means comprises biased
6 means attached to a closure member which biased
7 means is held in a biased position by means of
8 a liquid-sensitive material such that flow of
9 liquid in said annular space causes interaction
10 of said liquid with said liquid-sensitive
11 material causing said liquid-sensitive material
12 to release the biased means so that said biased
13 means effects movement of the closure member to
14 close said one or more orifices.
15
- 16 10 A seal assembly according to claim 9 wherein
17 the biased means is a spring.
18
- 19 11 A seal assembly according to claim 9 or 10
20 wherein the liquid-sensitive material is a
21 water-soluble salt.
22
- 23 12 A seal assembly according to any one of claims
24 7 to 12 wherein the annular member comprises
25 one or more tubes in which tubes the one or
26 more valves are situated.
27
- 28 13 A seal assembly according to any one of the
29 preceding claims wherein the annular member is
30 dimensioned so that it will extend from the
31 inner wall of the outer pipe to the outer wall
32 of the inner pipe and will be in sealing

- 1 contact with each of said inner and said outer
2 walls.
3
- 4 14 A seal assembly according to any one of claims
5 1 to 3 wherein
6 (a) the annular member is dimensioned so that
7 it will be sealing contact with only one
8 of the inner wall of the outer pipe and
9 the outer wall of the inner pipe and will
10 provide an opening in said annular space
11 between the annular member and the wall
12 with which it is not in sealing contact;
13 and
14 (b) the moveable blocking means comprises
15 resilient means which is deformable under
16 the pressure of liquid flow in the annular
17 space to close said opening.
18
- 19 15 A seal assembly according to claim 14 wherein
20 the annular member has a longitudinal end face
21 which has a recess to define upper and lower
22 arms and one of these arms is the resilient
23 means deformable under the pressure of liquid
24 flow in the annular space to close said
25 opening.
26
- 27 16 A seal assembly according to claim 13 or claim
28 14 which comprises annular restraining means
29 bonded to the upper and lower arms of the
30 annular member.
31

- 1 17 A pipe system comprising an inner and an outer
- 2 pipe and a seal assembly according to any one
- 3 of the preceding claims.
- 4
- 5 18 A valve suitable for use in the seal assembly
- 6 of any one of claims 7 to 12.
- 7

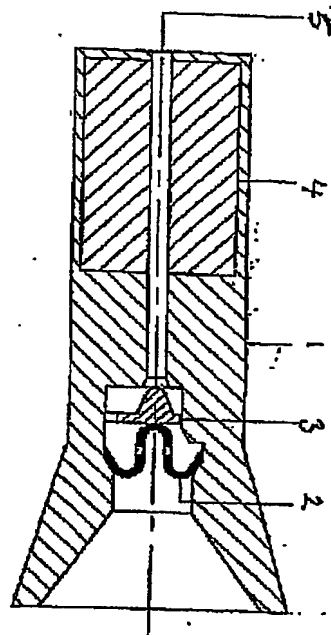


Figure 1a

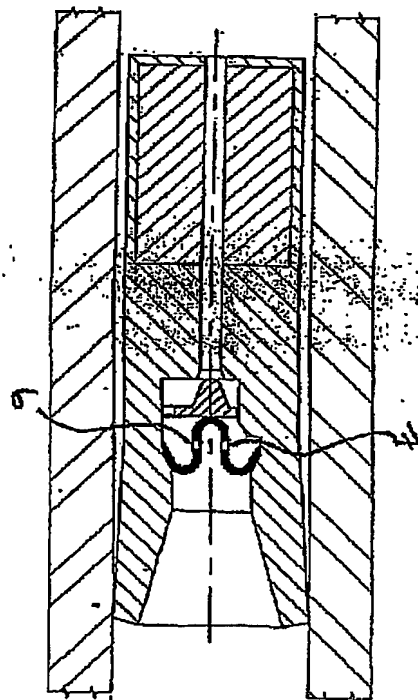


Figure 1b

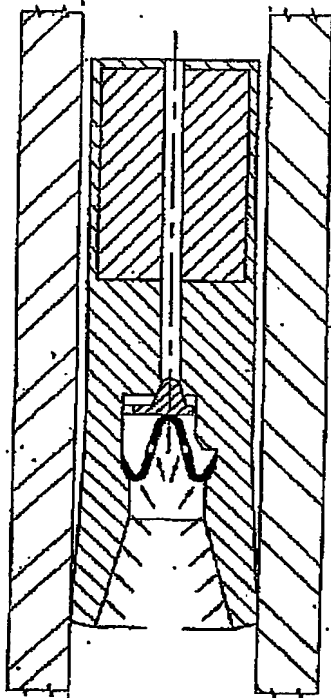


Figure 1c

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SECTIONAL ELEVATION

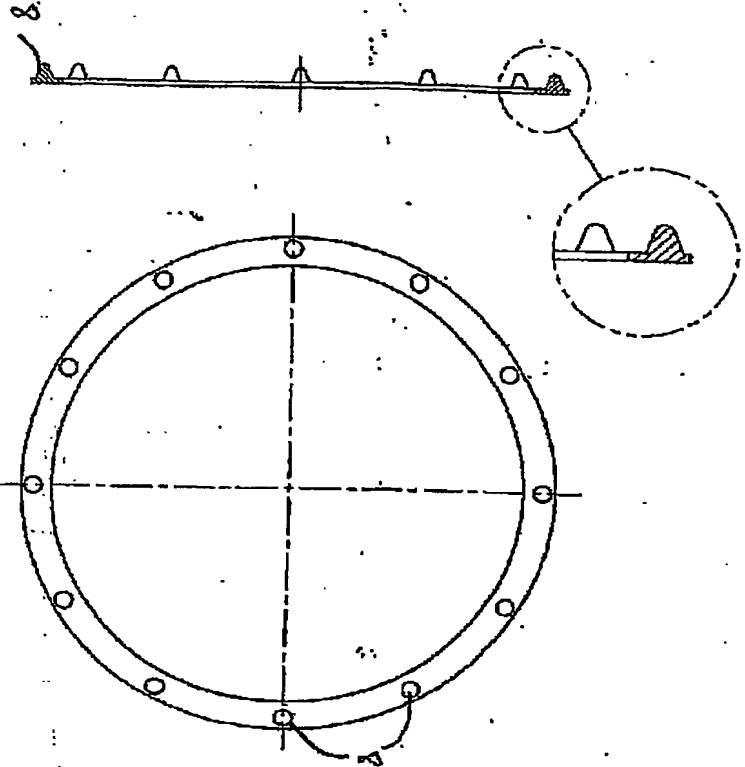


Figure 1a

SECTIONAL ELEVATION

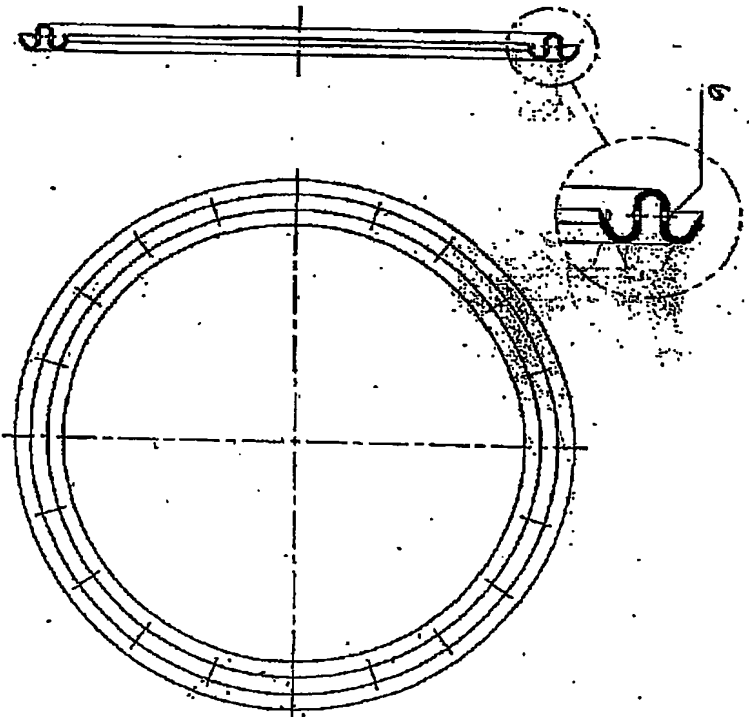


Figure 1e

Figure 2a

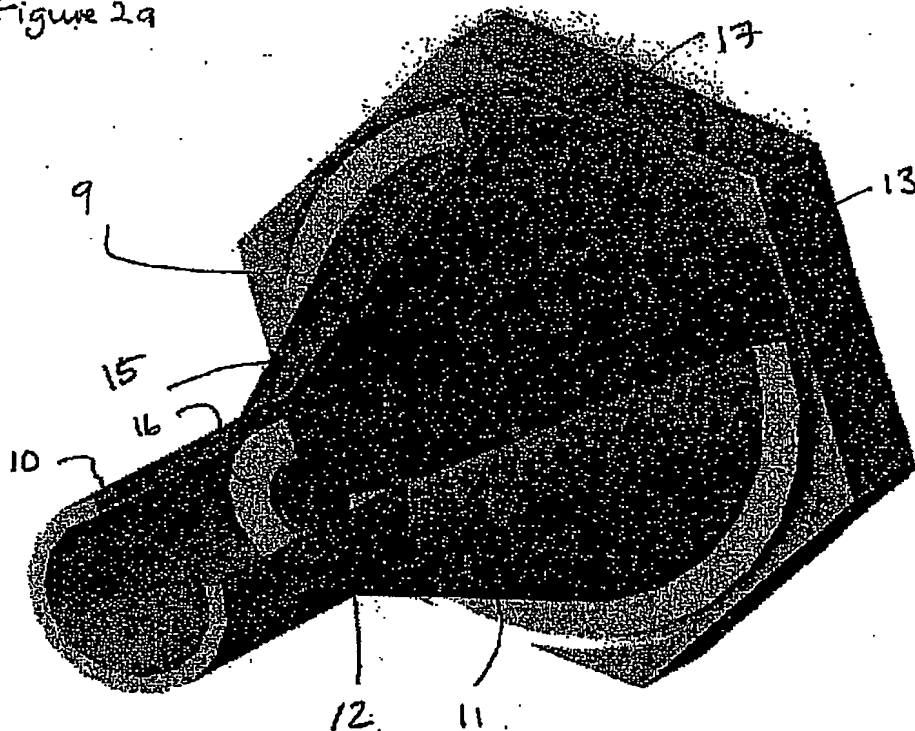
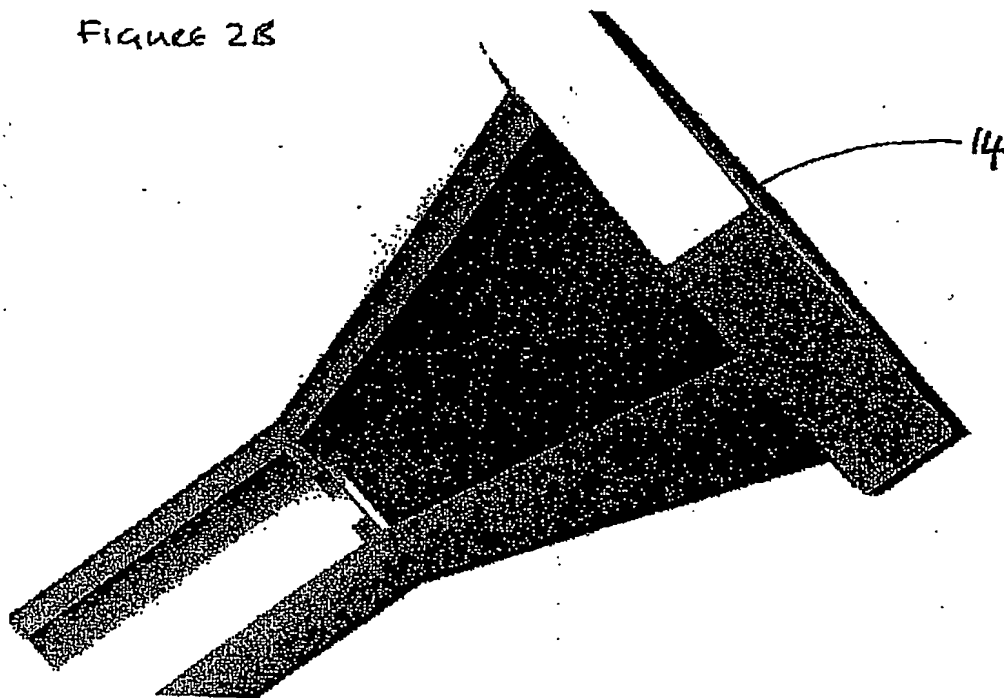


FIGURE 2B



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FIGURE 3a

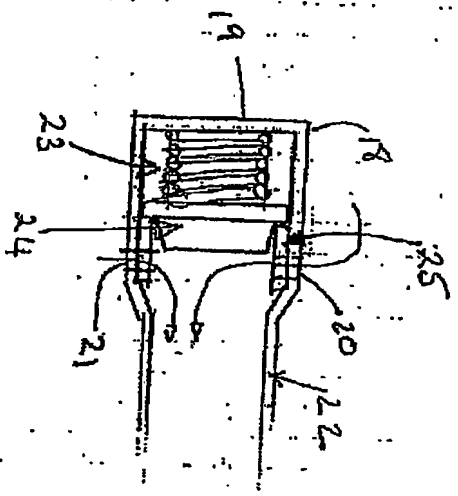


FIGURE 3b

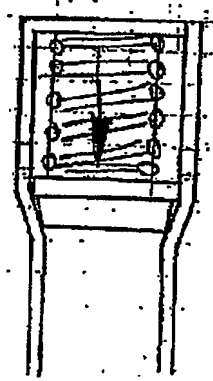


FIGURE 3c

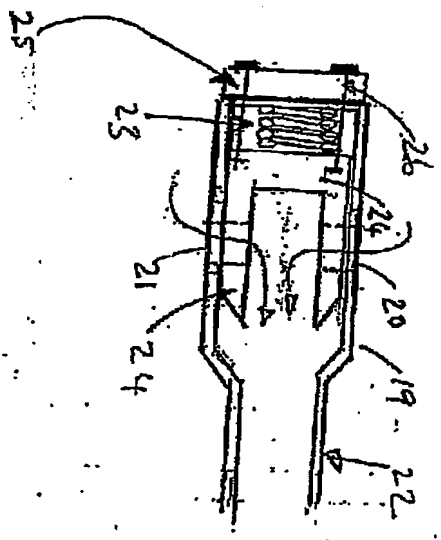


FIGURE 3d

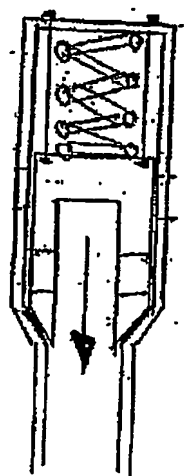


Figure 4a

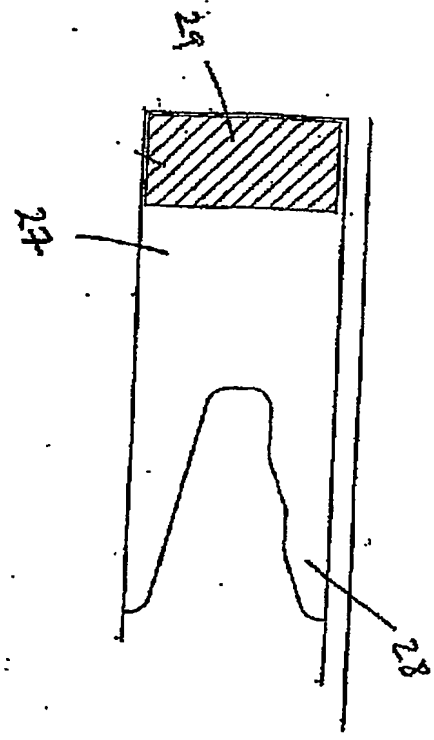


Figure 4c

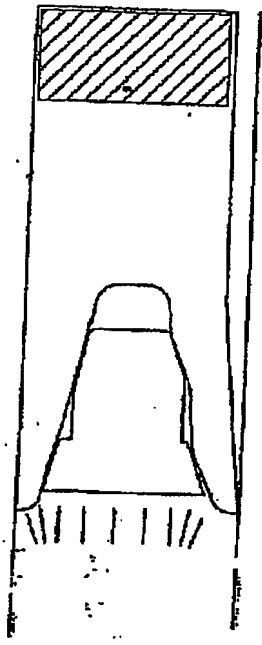


Figure 4b

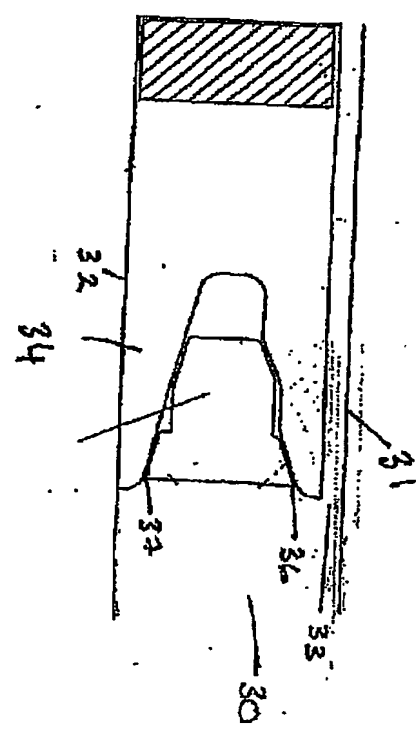


Figure 4d



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